Personalized Medicine:
Promise and Pitfalls from EHRs

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May 25, 2017

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Managing information is key to medicine

Listening to patients

Taking a history

Reviewing results

Reasoning

Weighing probabilities

Creating a differential diagnosis

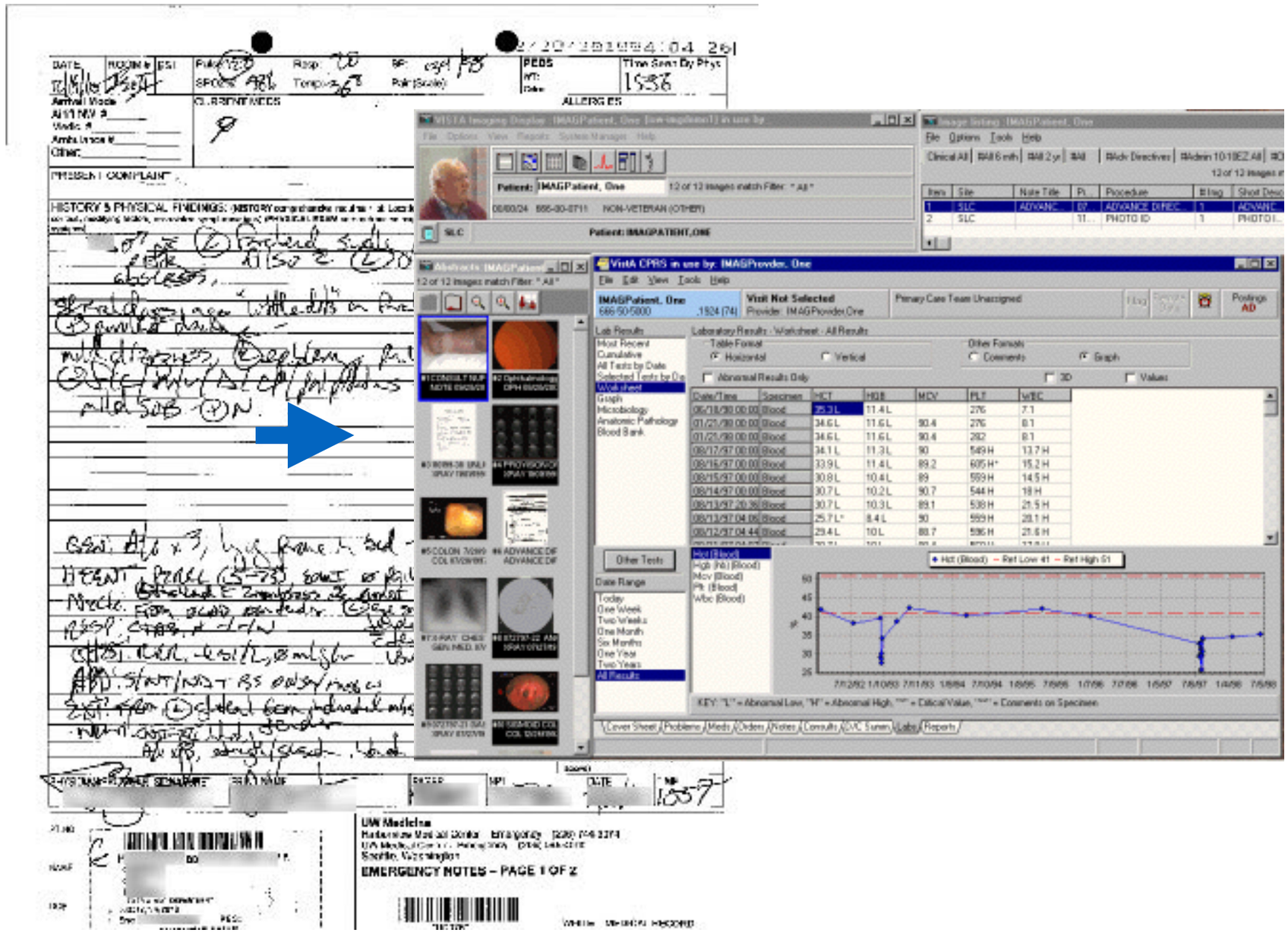
Entering orders

Communicating with others

Adjusting likely differential diagnoses

Managing populations

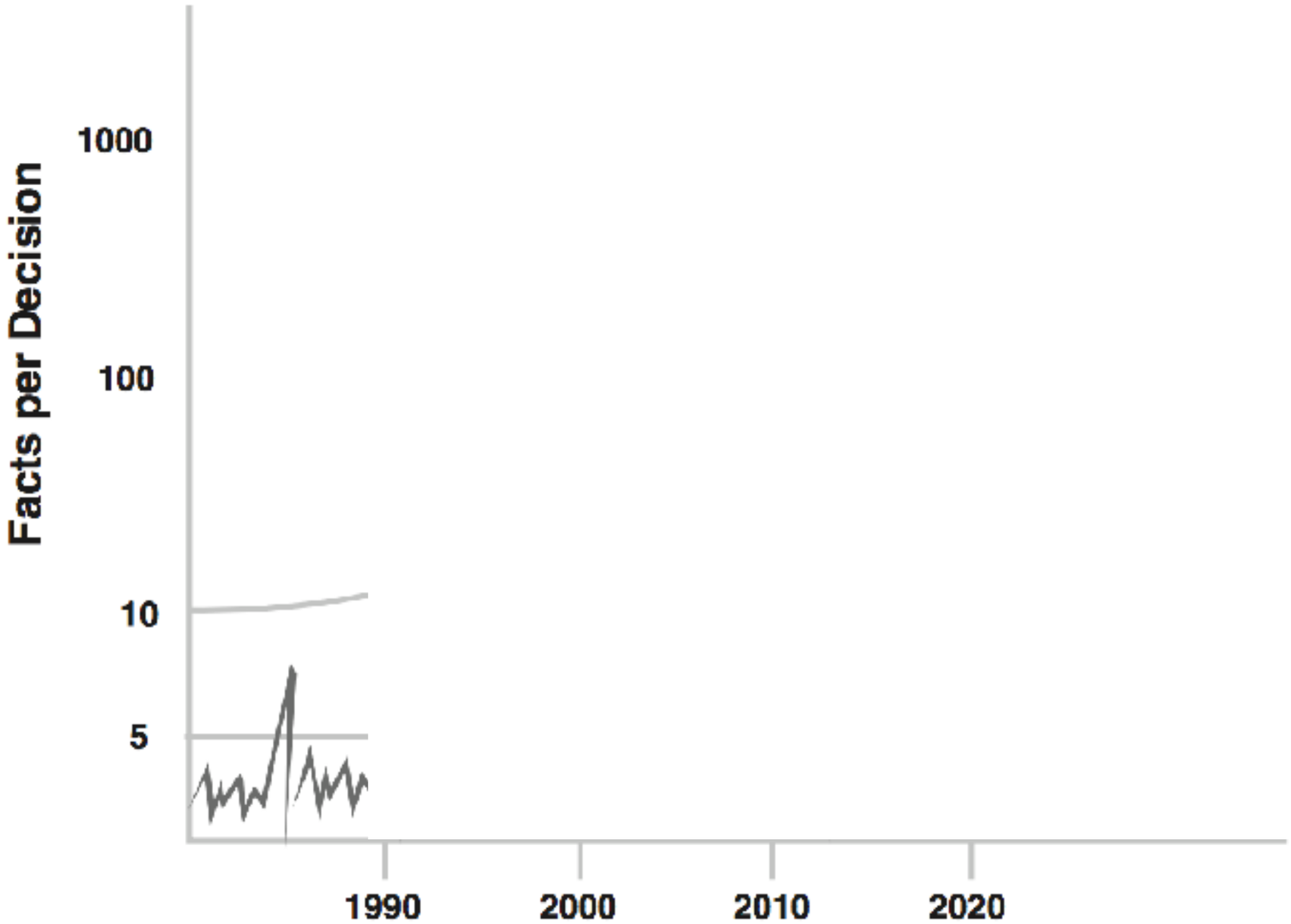
What is an electronic health record?



Evidence-based medicine

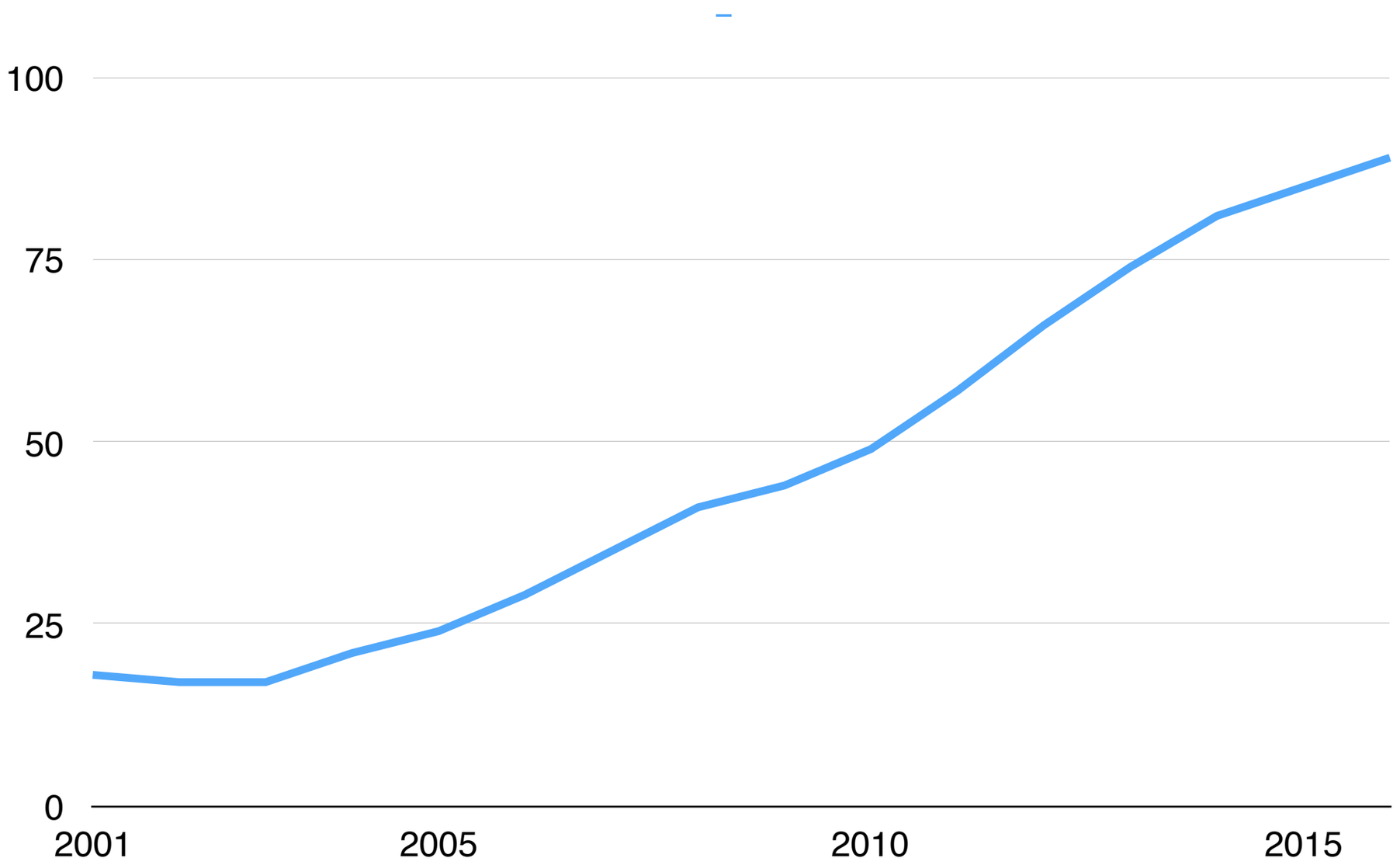
The gold standard is the randomized controlled trial.

Greenberg, in JACC Vol. 51, No. 11, 2008



[Masys and Stead, 2007]

US Physician EHR Adoption



2016 – 4924 hospitals (96%) & 493,612 MDs

One healthcare system

UW Medicine providers create over 3,600 electronic physician notes a day.

In a decade, we've created **~13 million notes.**

PROGRESS NOTE HOSPITAL DAY 2

CHIEF CONCERN

xx-year-old woman with a history of end-stage renal disease on peritoneal dialysis here with bacterial peritonitis

INTERVAL HISTORY

The patient feels relatively well this morning, though not back to normal. She notes that her blood pressure has been slightly low, however she denies lightheadedness. She has been up to the bathroom and back but has not walk further than this due to fatigue. She notes discomfort and irritation around the right thigh blister. This popped today and serous fluid onto her bed. She relates that her peritoneal dialysis fluid has cleared up compared with yesterday. She denies nausea or vomiting. She denies dyspnea, fever, or chills. She did have a PD cycle last night, and had antibiotic bath for a time as well.

PHYSICAL EXAM

Vital signs temperature 37 pulse 62 blood pressure 99/53 respiratory 14 oxygen saturation 96% on room air

General thin woman in no apparent distress. Heart has regular rate and rhythm with no murmurs gallops rubs. Lungs are clear on anterior examination. Abdomen is soft and nontender today. Peritoneal dialysis catheter in place. She has trace lower extremity edema. She has no rash on exposed skin.

LABS

Reviewed in ORCA. Notable for white blood cell count 12.8, hematocrit 26, platelets 173. Potassium 4.6. BP 152. Vancomycin trough pending.

ASSESSMENT AND PLAN

Patient is a 64-year-old woman with end-stage renal disease on peritoneal dialysis, here with resolving sepsis from peritonitis.

Coagulase-negative peritonitis Staph Hemodynamics are improving on antibiotics. Have discontinued IV antibiotics in favor of intraperitoneal, coordinated by the nephrology team. Blood pressure in the 90s systolically today off of stress dose steroids. We'll monitor closely overnight tonight. We'll check vancomycin trough.

Hypoxemia. This is resolved, and was likely due to septic physiology.

End-stage renal disease on PD. I appreciate nephrology consultations help. Continue peritoneal dialysis cycles per their recommendations.

Chronic hepatitis B. Continue entecavir.

General renal diet. Peripheral IV and peritoneal dialysis catheter. Subcutaneous heparin. Full code.

PROGRESS NOTE HOSPITAL DAY 2

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INTERVAL HISTORY

The patient **feels relatively well** this morning, though **not back to normal.** She notes that her blood pressure has been slightly low, however she denies lightheadedness. She has been **up to the bathroom** and back but has not walk further than this **due to fatigue**. She notes discomfort and irritation around the right thigh blister. This popped today and serous fluid onto her bed. She relates that her peritoneal dialysis fluid has cleared up compared with yesterday. She denies nausea or vomiting. She denies dyspnea, fever, or chills. She did have a PD cycle last night, and had antibiotic bath for a time as well.

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SYMPTOMS

Feels relatively well
Not back to normal
Has been up to the backroom
Fatigue prevented further walking
Right thigh discomfort and blister
Blister popped
Serous fluid drained
Peritoneal dialysis fluid clearer than yesterday
Blood pressure slightly low
Declines lightheadedness

EXAM

T 37 P 62 BP 99/53 RR 14 O2sat 96% RA
Thin
No apparent distress
Heart regular rate and rhythm
No heart murmur
No heart gallop
No cardiac rub
Lungs clear to anterior exam
Abdomen soft, no tender
Peritoneal dialysis catheter in place
Trace leg edema
No skin rash on exposed skin

LABS

Clinician believes these are the most relevant labs:

WBC 12.8
Hematocrit 26
Platelets 173,000
Vancomycin trough orders and pending

ASSESSMENT

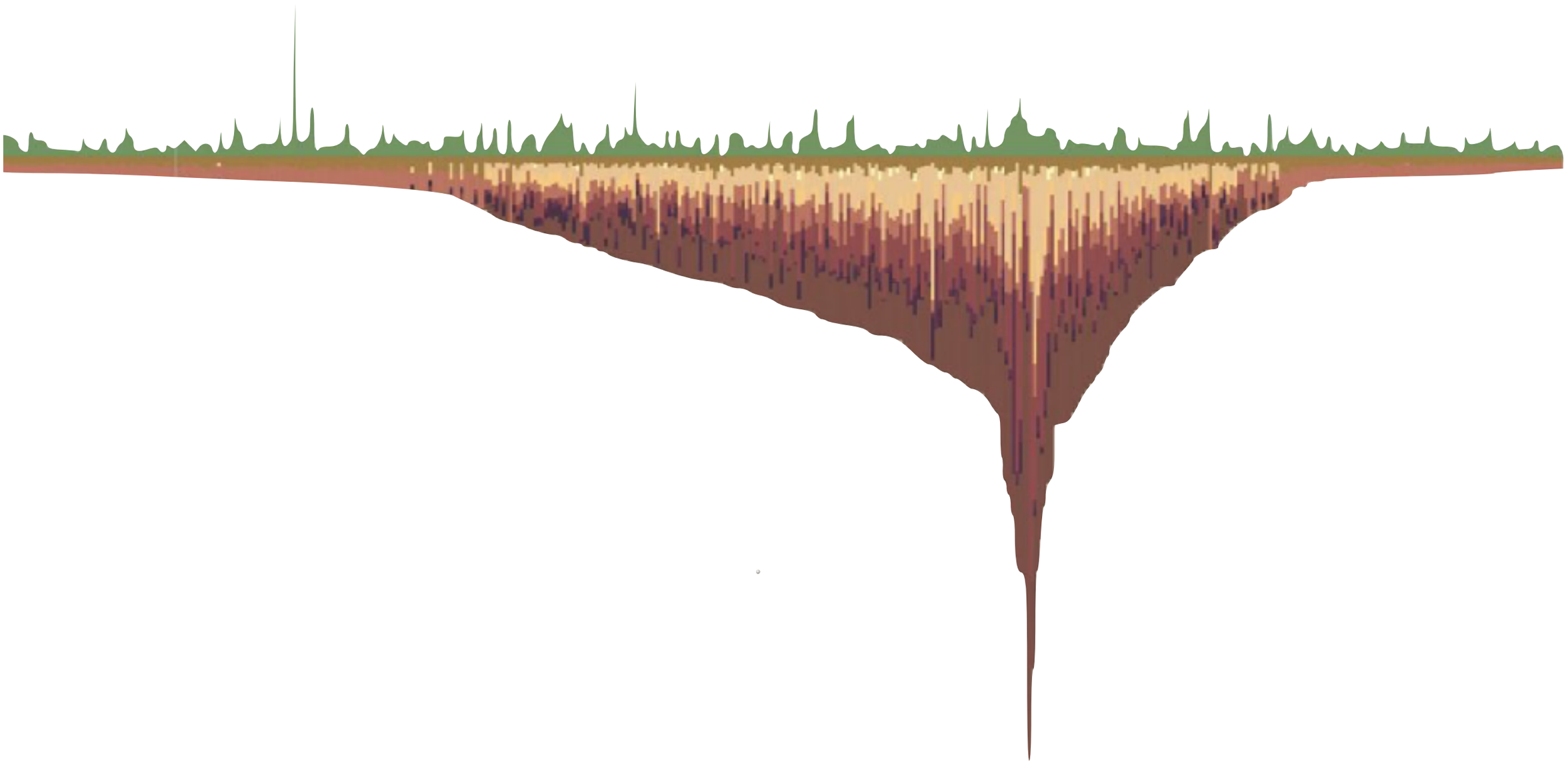
Sepsis due to peritonitis is resolving
Due to coagulase-native Staph
Hemodynamics are improving on antibiotics
Stopped IV antibiotics
Antibiotics given intraperitoneal route
BP in 90s while off stress dose steroids.
Hypoxemia resolved.
Cause of hypoxemia was sepsis

PLAN

Monitor blood pressure
Continue antibiotics via intraperitneal route
Monitor vancomycin trough level
Continue enecavir for hepatitis B
General renal diet
Subcutaneous heparin (to prevent VTE)
She is full code
Continued nephrology consultation

She has a peripheral IV
She has a peritoneal dialysis catheter

The potential to learn



POLICY

Achieving a Nationwide Learning Health System

Charles P. Friedman,* Adam K. Wong, David Blumenthal

Published 10 November 2010; Volume 2 Issue 57 57cm29

We outline the fundamental properties of a highly participatory rapid learning system that can be developed in part from meaningful use of electronic health records (EHRs). Future widespread adoption of EHRs will make increasing amounts of medical information available in computable form. Secured and trusted use of these data, beyond their original purpose of supporting the health care of individual patients, can speed the progression of knowledge from the laboratory bench to the patient's bedside and provide a cornerstone for health care reform.

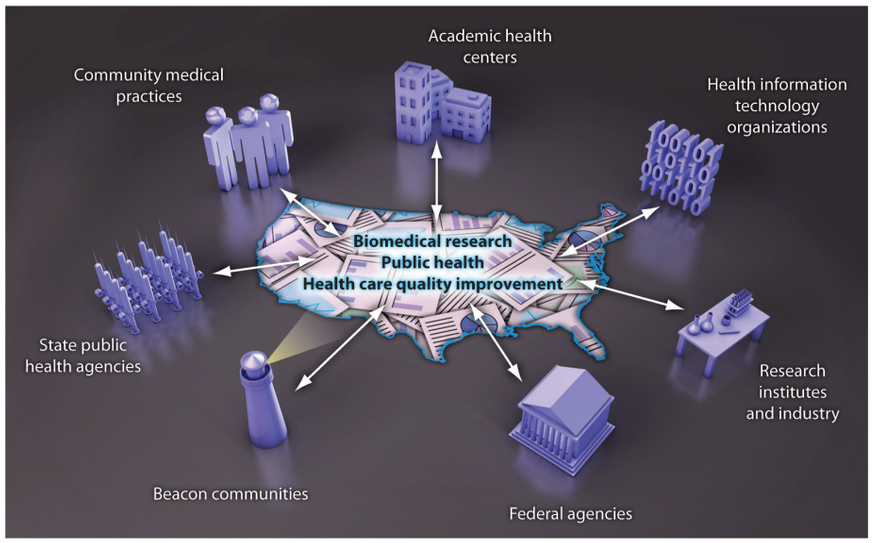
According to conventional wisdom, 17 years elapse before a new element of validated clinical knowledge finds its way into routine clinical practice in the United States (*1*). Although there is undoubtedly considerable variance around this estimate, the latency between biomedical discovery and care implementation is clearly too great. A more efficient, effective, and safe health care system requires a more rapid progression of knowledge from the lab bench to the bedside. Adoption of health information technology and trusted "meaningful use" (*2*) of patient data can help speed this process. In this Commentary, we present our vision of a nationwide biomedical learning system and describe the key contributory roles of meaningful use and additional components required to move the United States in its entirety toward this critical goal.

THE POTENTIAL: HEALTH INFORMATION TECHNOLOGY ADOPTION AND MEANINGFUL USE

The American Recovery and Reinvestment Act of 2009 introduced the concept of meaningful use of health information technology to improve health care and population health across the United States and authorized the payment of incentives to eligible health professionals and hospitals that achieve meaningful use. Meaningful use requires adoption of certified electronic health records (EHRs), secure mobility of health information, and reporting of quality measures (*3*). As the United States progresses toward President Obama's goal that every American will benefit from an EHR, massive amounts of clinical information will be stored in electronic form (*4*). At the same time, achievement of meaningful use of these EHRs will enable this clinical information to flow securely from the site where it was collected to a different location where the information has an authorized use. In practice settings that achieve meaningful use, the clinical information will be represented by using precisely defined standards that have been adopted for use throughout the United States. Standardized representations ensure that the meaning of clinical information is preserved as the data move to new locations.

The accumulation through EHR adoption of these computable, liquid, standardized data creates an enormous potential for the U.S. health system to conduct clinical and translational research, assess and improve the quality of health care, and survey the health of the public at speeds approaching real time. These goals can be achieved by moving data, on an as-needed basis, from the panoply of locations where they are collected to one or more investigative centers where they are aggregated and analyzed for a specific purpose. Rapid data aggregation enables the creation of large, scientifically valid samples that can then be used to draw powerful inferences about populations. When this process can happen routinely, with mechanisms in place to establish and maintain public trust that the process is secure and private, the nation will have substantially progressed toward establishing a so-called rapid learning health system (*5*–*7*).

Adoption and meaningful use of EHRs are necessary to establish a nationwide learning health system and to create a foundation for its construction. Therefore, federal resources that directly promote the adoption and meaningful use of EHRs also move the nation toward a learning system (*8*). However, although necessary, EHR adoption and meaningful use are not sufficient to achieve this goal; additional components are required to achieve our vision of a highly participatory biomedical learning system in the United States (Fig. 1).



CREDIT: C. BICKEL/*SCIENCE TRANSLATIONAL MEDICINE*

Fig. 1. A nationwide network. Meaningful use of EHRs, widespread participation by multiple diverse entities, and an appropriate technical architecture can spur the construction of a highly participatory rapid learning system that stretches from coast to coast. The resulting rapid learning system can be used, for example, to support biomedical research and augment public health data, with the ultimate goal of improving the quality of health care.

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over the past decade. We must do better over the next decade. EHRs can improve the safety and culture of U.S. health care, but only if the federal government, as the nation's largest health care payer, demonstrates that it is serious about improving patient safety.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

From the Department of Health Policy and Management, Harvard School of Public Health, and the VA Boston Healthcare System — both in Boston (A.K.J.); and Computer Sciences Corporation and the University of Utah — both in Salt Lake City (D.C.C.).

1. Landrigan CP, Parry GJ, Bones CB, Hackbarth AD, Goldmann DA, Sharek PJ. Temporal trends in rates of patient harm resulting from medical care. N Engl J Med 2010;363:2124-34. [Erratum, N Engl J Med 2010;363:2573.]
2. Levinson D. Adverse events in hospitals: national incidence among Medicare beneficiaries. Washington, DC: Office of the Inspector General, Department of Health and Human Services, 2010.
3. Classen DC, Resar R, Griffin F, et al. 'Global trigger tool' shows that adverse events in hospitals may be ten times greater than previously measured. Health Aff (Millwood) 2011;30:581-9. [Erratum, Health Aff (Millwood) 2011;30:1217.]
4. Chassin MR, Loeb JM, Schmaltz SP, Wachter RM. Accountability measures — using measurement to promote quality improvement. N Engl J Med 2010;363:683-8.
5. Hospital quality initiatives: outcome measures. Baltimore: Centers for Medicare & Medicaid Services, 2011 (https://www.cms.gov/HospitalQualityInits/20_OutcomeMeasures.asp).

Evidence-Based Medicine in the EMR Era

Jennifer Frankovich, M.D., Christopher A. Longhurst, M.D., and Scott M. Sutherland, M.D.

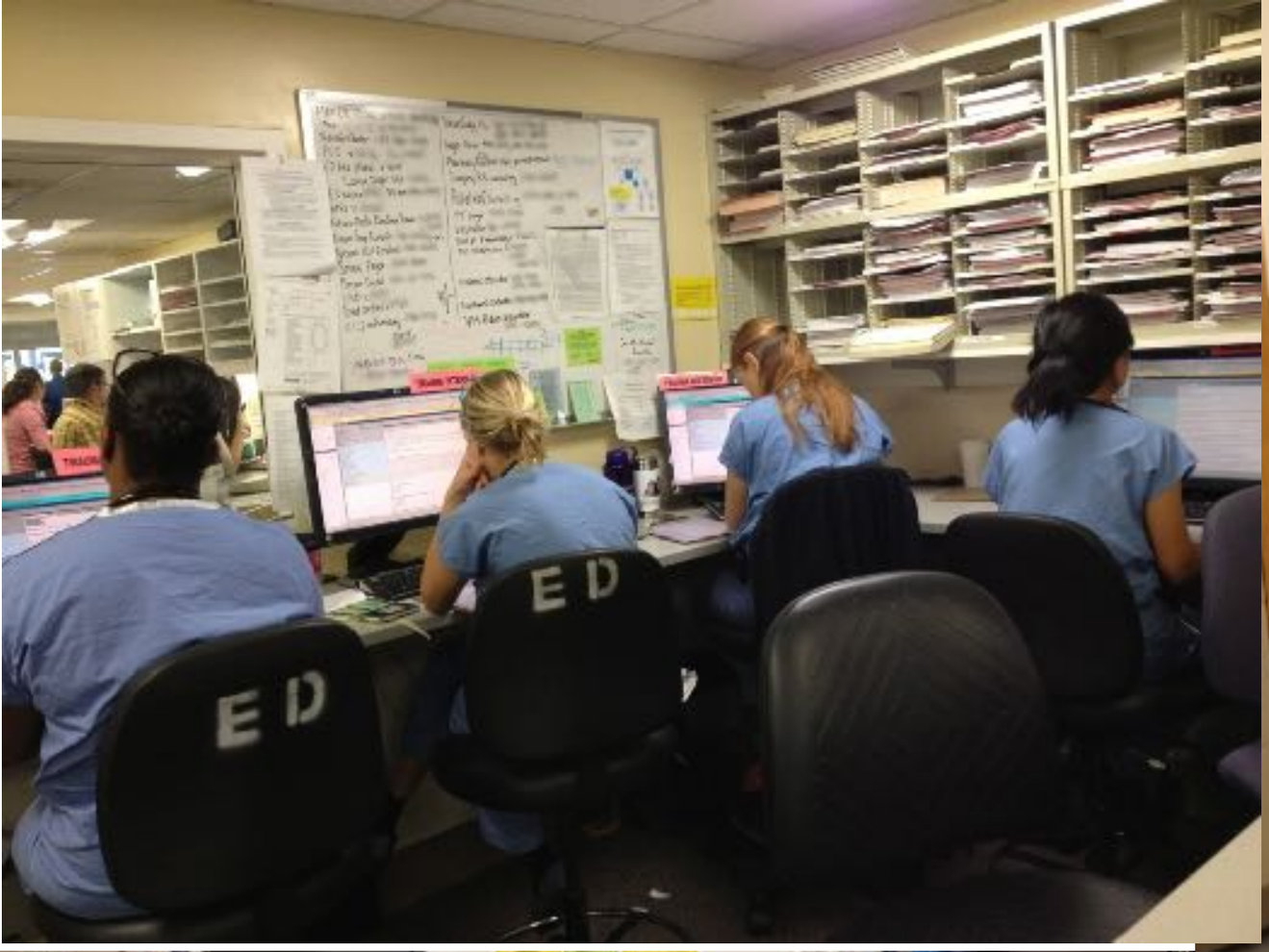
Many physicians take great pride in the practice of evidence-based medicine. Modern medical education emphasizes the value of the randomized, controlled trial, and we learn early on not to rely on anecdotal evidence. But the application of such superior evidence, however admirable the ambition, can be constrained by trials' strict inclusion and exclusion criteria — or the complete absence of a relevant trial. For those of us practicing pediatric medicine, this reality is all too familiar. In such situations, we are used to relying on evidence at Levels III through V — expert opinion — or resorting to anecdotal evidence. What should we do, though, when there aren't even meager data available and we don't have a single anecdote on which to draw?

We recently found ourselves in such a situation as we admitted to our service a 13-year-old girl with systemic lupus erythematosus (SLE). Our patient's presentation was complicated by nephrotic-range proteinuria, antiphospholipid antibodies, and pancreatitis. Although anticoagulation is not standard practice for children with SLE even when they're critically ill, these additional factors put our patient at potential risk for thrombosis, and we considered anticoagulation. However, we were unable to find studies pertaining to anticoagulation in our patient's situation and were therefore reluctant to pursue that course, given the risk of bleeding. A survey of our pediatric rheumatology colleagues — a review of our collective Level V evidence, so to speak — was equally fruitless and failed to produce a consensus.

Without clear evidence to guide us and needing to make a decision swiftly, we turned to a new approach, using the data captured in our institution's electronic medical record (EMR) and an innovative research data warehouse. The platform, called the Stanford Translational Research Integrated Database Environment (STRIDE), acquires and stores all patient data contained in the EMR at our hospital and provides immediate advanced text searching capability.[1] Through STRIDE, we could rapidly review data on an SLE cohort that included pediatric patients with SLE cared for by clinicians in our division between October 2004 and July 2009. This "electronic cohort" was originally created for use in studying complications associated with pediatric SLE and exists under a protocol approved by our institutional review board.

Of the 98 patients in our pediatric lupus cohort, 10 patients developed thrombosis, documented in the EMR, while they were acutely ill. The prevalence was higher among patients who had persistent nephrotic-range proteinuria and pancreatitis (see table). As compared with our patients with lupus who did not have these risk factors, the risk of thrombosis was 14.7 (95% confidence interval [CI], 3.3 to 96) among patients with persistent nephrosis and 11.8 (95% CI, 3.8 to 27) among those with pancreatitis. This automated cohort review was conducted in less than 4 hours by a single clinician. On the basis of this real-time, informatics-

The pitfalls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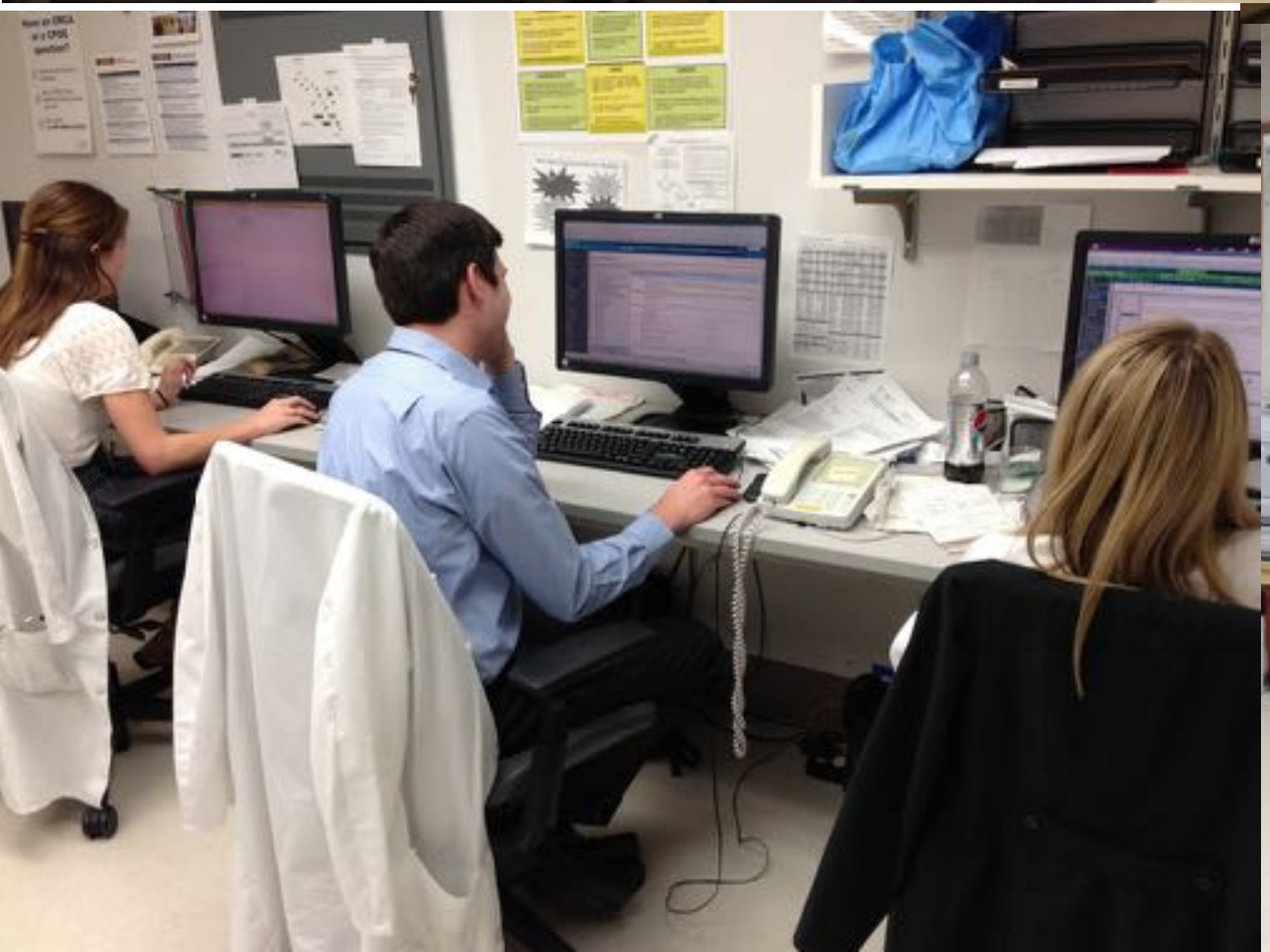

ID/CC/Injury list: 159 yo female with recurrent chronic pancreatitis now S/P multiple drain placements

Subjective/Interval Hx:
Midline epigastric abdominal pain moderately controlled, patient tearful, wants to go home for birthday. Extremely thirsty. No dysuria, no pain at IV sites.

Objective

Physical Exam
T 36.1 P 95 BP 135/69 RR 16, O2sat 100
Gen: laying in bed, thirsty
HEENT: NGT/NJT
Chest: Dull with diminished breath sounds at both bases
CV Regular rhythm, S1S2 normal with Gr 2/6 systolic m
Abd: Less distended firm but compressible, diffusely moderately tender without rebound/percussion tenderness. Drains in place with thin purulent non-sanguinous output

I&O
po 1.5, 300 Irrigation, Urine output 5.3, NG output 3.3, Suprapubic pigtail 115, R flank drain 95, L flank drain 130

Studies (Labs/Cultures/Path) <new each day>
Assessment
159 yo woman with recurrent chronic pancreatitis transferred from elsewhere. Three drains per IR in intraabdominal fluid collections, now on cefepime and flagyl. Growing D coli, viridans strep, and anaerobic GNR from drain sites no changes to cultures today.

1. Renal failure. Creatinine improving, unclear etiology of renal failure. likely multifactorial. Will consider nephrology consult if no improvement in creatinine

2. Pancreatitis. Not toxic, pain adequately controlled, antimicrobial coverage adequate. ERCP next week per GI. Will contact if concern for cholangitis.

3. Depressive disorder. Psych consulted previously for management of previously diagnosed depressive disorder likely exacerbated by current illness - appreciate their input

Plan

1. Replace suprapubic drain with 18fr today
2. Allow ad lib water/ice chips x 24 hours
3. ERCP this week per GI

ID/CC/Injury list: 69 yo female with recurrent chronic pancreatitis now S/P multiple drain placements

Subjective/Interval Hx:
Today pain much improved. Had ent Sat without problems. No dysuria or line pain.

Objective

Physical Exam
T 36.4 P 69 BP 135/84 RR 15, O2sat 99
Gen: In bed, smiling intermittently
HEENT: NI: No sclera icterus
Chest: Anterior fields clear
CV Regular, nc murmur heard
Abd: Drains remain in place. Active bowel sounds. Non-tender to moderate palpation

I&O
po 3.0, 50 Irrigation, Urine output 6.5, NG output 3.4, Suprapubic pigtail 53, R flank drain 15, L flank drain 25

Studies (Labs/Cultures/Path) <new each day>
Assessment
199 yo woman with recurrent chronic pancreatitis transferred from elsewhere. Clinical picture is that of resolving chronic pancreatitis with aseptic fluid collection. She's generally improving

1. Renal failure. Close to resolution. No need for Renal consultation. Probably due to intravascular volume depletion +/- ATN

2. Pancreatitis. As above. Picture does not suggest infection. Suspect will not need ERCP this admission

3. Depressive disorder. Mood has improved as general condition has improved

Plan

1. Anticipate removal of other drains if continued decline in output.
2. Advance to regular diet
3. Discharge planning conference tomorrow.

ID/CC/Injury list: 69 yo female with recurrent chronic pancreatitis now S/P multiple drain placements

Subjective/Interval Hx:
Midline epigastric abdominal pain moderately controlled, patient tearful, wants to go home for birthday. Extremely thirsty. Again: No dysuria, no pain at IV sites

Objective

Physical Exam
T 36.0 P 93 BP 109/80 RR 16, O2sat 100
Gen: laying in bed, thirsty
HEENT: NGT/NJT, as/o
Chest: Dull with diminished breath sounds at both bases
CV Regular rhythm, S1S2 normal with Gr 2/6 systolic m
Abd: Less distended firm but compressible, diffusely moderately tender without rebound/percussion tenderness. Drains in place with thin purulent non-sanguinous output (no change)

I&O
po 1.5, 300 Irrigation, Urine output 5.3, NG output 3.3, Suprapubic pigtail 115, R flank drain 95, L flank drain 130

Studies (Labs/Cultures/Path) <new each day>
Assessment
159 yo woman with recurrent chronic pancreatitis transferred from elsewhere. Three drains per IR in intraabdominal fluid collections, now on cefepime and flagyl. Growing D coli, viridans strep, and anaerobic GNR from drain sites no changes to cultures today.

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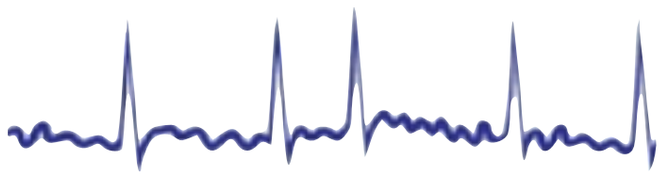
3. Depressive disorder. Psych consulted previously for management of previously diagnosed depressive disorder likely exacerbated by current illness - appreciate their input

Plan

1. Replace suprapubic drain with 18fr today DONE YEST
2. Allow ad lib water/ice chips x 24 hours
3. ERCP this week per GI

MAY IS NATIONAL STROKE AWARENESS MONTH

STOP Stroke • Act F.A.S.T. • Spread HOPE



https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_atrial_fibrillation.htm

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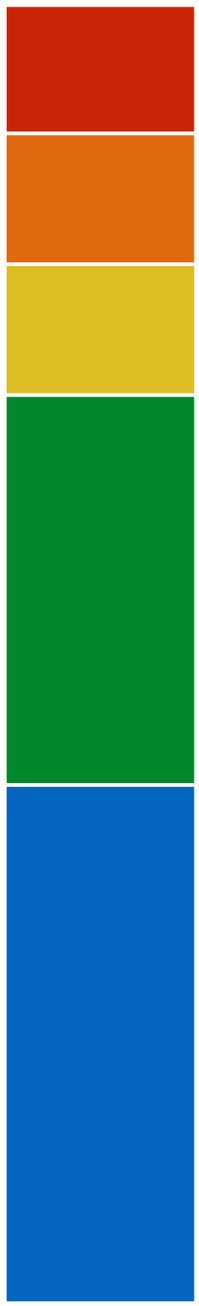
What if we could find people with atrial fibrillation from their records?

Inaccurate documentation	11 (4.4)	60 (24)	71 (14.2)	<.001
Permanent atrial fibrillation	4 (8)	16 (32)	20 (20)	<.05
CVA with hemiparesis	2 (4)	10 (20)	12 (12)	<.05
Severe aortic stenosis	4 (8)	20 (40)	24 (24)	<.001
Lower limb amputation	1 (2)	14 (28)	15 (15)	<.001
Intubation	0	0	0	
Physical examination finding not documented	103 (41.2)	44 (17.6)	147 (29.4)	<.001
Permanent atrial fibrillation	17 (34)	6 (12)	23 (23)	<.001

JAMIA 24(1), 2017, 140–144



Clinical care

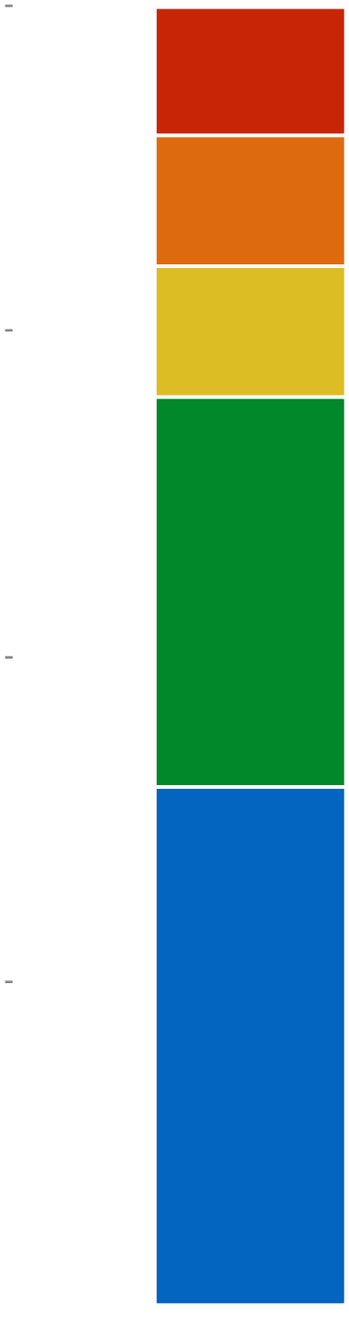
Genes & biology

Physical environment

Health behaviors

Social & economic factors

http://www.health.state.mn.us/divs/che/about/creatinghealthequity.html

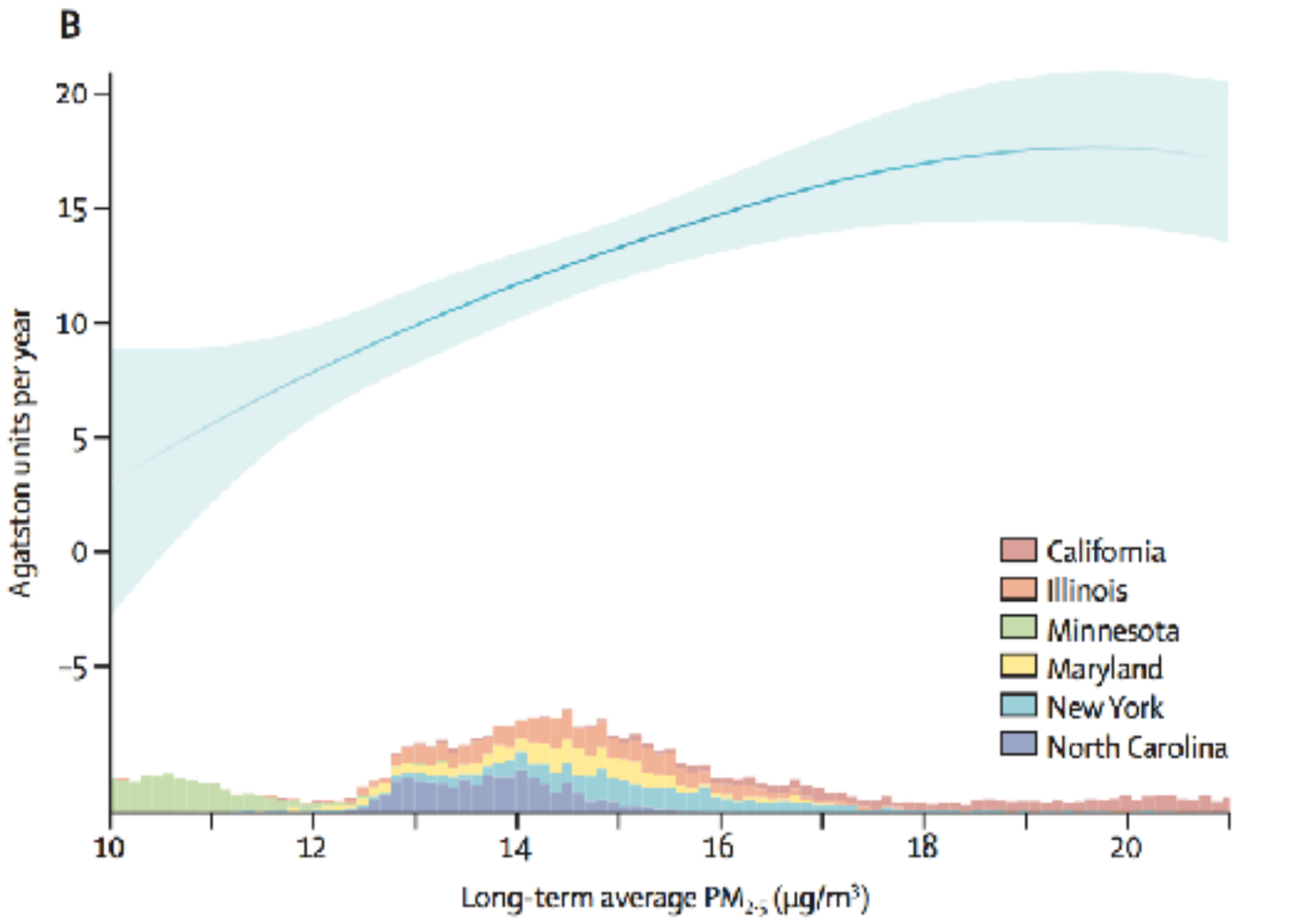


Genes & biology

Colorectal cancer screening

60
50
40
30
20

Physical environment



Lancet 2016; 388: 696–704

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Our future

1. Dramatic improvements in EHR usability
2. Using EHRs to learn from the process of care: Learning Healthcare System
3. Focus on most important determinants of health.

Thank you!

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